Art. V.—*Notes on some Evidences of Glaciation in the Australian Alps.*

Article I.

By James Stirling, F.L.S., F.G.S.

[Read 9th July, 1885.]

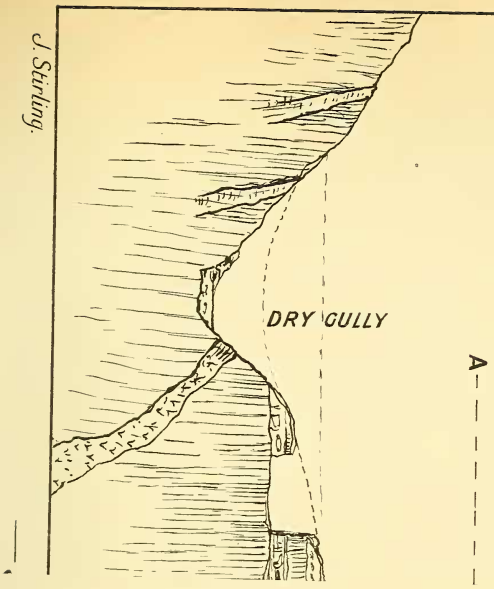
On examining a map of Victoria, it will be seen that the watershed line of the main Dividing Range is deflected south-easterly from Mount Hotham, round the sources of the Livingstone Creek, forming a somewhat parabolic curve. It is in this area that the evidences of glaciation herein described are to be seen, consisting of the following:—

1. Grooved, striated, and shattered rock surfaces.
2. Heavy transported boulders, bouldery wash-clays, and auriferous gravels.
3. Erratics and morainic débris.
4. Glaciated contour of country and eroded lake-basins.
5. Roches moutonnées.

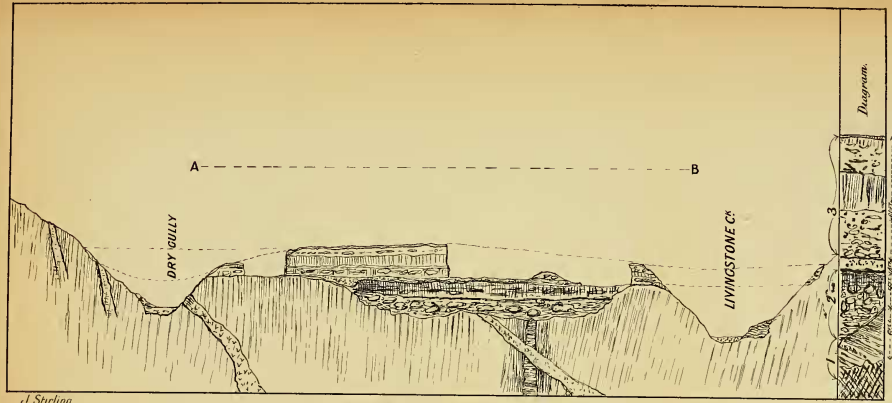
In the following pages I have endeavoured to describe the various phenomena which seem to me to represent the evidence of glacial action, giving in some instances rather detailed geological descriptions, which, independent of the glacial evidences, may prove interesting as supplying information of a scientific character of this little-known area. I have described each valley separately, in order that a clearer picture of their physiography may be produced. These valleys comprise the Victoria River, Livingstone Creek, and the Benambra Creek, the latter margining the Omeo Plains; but in the present article I confine my remarks to the two former.

Victoria Creek Valley.

Rising in the Paw-Paw tableland on the main Divide, at an elevation of 5000 feet above sea-level, the Victoria Creek has eroded its present channel—first through the



where outcrops of silurian slates are found, and where the



J. Sterling.

— SECTION ACROSS DRY HILL — near OMEO —

— Scale: Vertical 100 feet to 1 Inch —

— do Horizontal 8 chs. to 1 do —

tertiary basalts, and then into some hard crystalline (gneissose) rocks. Unlike many other streams which have cut their way through these old lava flows—notably, the Dargo River—there are no bold escarpments of pentagonal basaltic columns, but the sides of the valley have been planed down in uniform slopes, presenting rather an undulating appearance for the first four or five miles. At lower levels, the hard gneissose rocks are seen to be planed and rounded in the direction of the main valley, giving to them a moutonné appearance. On examining the surface of some blocks standing out from the black peaty soil in the narrow sub-alpine flats, their surfaces are seen to be striated by parallel groovings in the direction of the valley, viz., east and west; and that these markings cut the strike of the bedding of the rocks at an angle of 25° to 30°, the latter being 60′ to 65′ N.W. At a point lower down (not more than half-a-mile distant), the watercourse has eroded a channel through a somewhat narrow gorge, the steep rocky spurs on each side being composed of gneiss and other coarse micaceous schists. At various points of low spurs, masses of red earth, in which are angular fragments of metamorphic and basaltic rocks, are found, and generally at heights varying between twenty and thirty feet above the level of the present watercourse. About six miles lower down the valley widens, and a good depth of alluvium forms some open flats known as Parslow's Plains. On examining some superficial detritus on the hill-sides overlooking the flat to the north, remnants of yellow indurated clays, similar to those at Cobungra, are found. These laminated clays have evidently been brought from old miocene river beds similar to those at the sources of the Cobungra, some twelve miles distant, and at the higher levels. The fact of finding these fragments here seems to me sufficient proof that they were not washed down by the translocating agency of running water, otherwise it seems hardly possible that these clays would not have been long since worn by attrition to fine powder or sediment. In the creek bed which winds sinuously through the Parslow's Plain are masses of large waterworn boulders of basalt, some of which are flattened on one side, and striated altogether distinct from ordinary weathering or the action of running water. At lower levels, the Victoria receives an affluent from the south called Spring Creek, which rises at the Dividing Range near Mount Phipps, where outcrops of silurian slates are found, and where the

passage from unaltered slates to completely metamorphosed schists may be well seen—the slates occupying the fall towards the Dargo River, and the crystalline schists that of the Victoria Valley.

This creek traverses generally well-timbered pastoral country, the geological structure composed principally of metamorphic schists, which are penetrated by numerous diabasic, dioritic, and porphyritic dykes. At various bends in the valley, where it narrows, masses of water-worn shingle and igneous boulders are seen associated with what is evidently a morainic débris of metamorphic schists, igneous dykes and granite, left probably by a retreating subsidiary glacier which once filled the valley. The watershed being so small, there does not seem to be any possibility of running water having deposited these masses of débris in the situation where they now occur. At the junction of the two streams some of the more dense boulders of andesite are seen to be striated in a similar manner to the specimens, No. 1, now exhibited in illustration of this paper. About two miles further on—below Parslow's homestead—several small water-courses enter from the south: the principal of these from a locality known as Victoria Plains, a natural ice-scooped basin in the valley to the south, presenting on the whole a distinctively moutonné aspect. It was Victoria Plains that the Vice-Regal party, accompanied by the Surveyor-General and late Secretary for Mines, passed through en route from Omeo to Bright, and the scenery of which is so eloquently described in their narrative, page 38, of "Physical Resources of North Gippsland," that I cannot refrain from quoting it, as follows:—"We diverged from our path in order to see Victoria Plains; we saw it with the afternoon sun on it. It is not flat, but slightly undulating; it is in the form of long, low smooth banks or ridges running parallel to each other, with hollows not so deeply sculptured as to become watercourses. The lights thrown across the furrowed surface, gilding the low ranges and leaving the hollows in shadow, lent a beauty to this sequestered spot which under other circumstances it might not present; set in a frame of forest, itself destitute of timber and richly grassed, it made a picture altogether strange and startling, entering upon it as we did suddenly and with no idea of the character of the landscape which was to open to our view." The smooth banks or ridges—sowbacks—above referred to are, I think, clearly due to glacial abrasion. An examination of the

boulders and débris at the lower levels where the valley narrows and where the watercourse has cut through a hard bar of quartz-porphyry and dense gneiss, tends to confirm this impression, revealing other evidences in the shape of striated boulders of yellow felsitic (micro-porphyritic) dykes on the hill-sides. A few miles below this point the Victoria Valley suddenly narrows (the hills on either side rounded and planed down), and the watercourse falls into a deep gorge towards the Cobungra River. The elevation of Parslow's Plains is 3000 feet above sea-level. On considering the evidences of glaciation in this valley, I think we are justified in inferring that the Victoria and Spring Creeks, together with the sub-alpine basin at Parslow's Plains, was occupied by large masses of ice during later Pleistocene times. The great amount of erodation which has taken place elsewhere, notably in the Dargo River valley, on the southern side of the main Dividing Range, is in striking contrast with the small amount visible in the upper sources of the Victoria Creek, where denudation has been less active. These valleys would to a great extent be sheltered from the influence of northern or north-western hot winds by the high Bogong Ranges, while the Dargo is open to the more constant precipitation of south-west and south moisture-laden winds, so that long after the maximum of glaciation had occurred the valleys of the Victoria Creeks would retain their icy mantles.

Livingstone Creek Valley.

Embracing an area of 138 square miles, with a total length of 31 miles, this valley slopes uniformly from the open moorland flats near its sources, in the main Divide, to the Hinnomunjie Flats at the junction with the Mitta Mitta River. The elevation of the Dividing Range at the sources of the Livingstone Creek is 4500 feet, and of the Hinnomunjie Flats about 1800 feet. The typical silurian slates and sandstones of the goldfields occupy the southern crest of the Divide and the fall towards the Wentworth River. About six miles further south, in the valley of the latter, are extensive outcrops of a grey quartz conglomerate and coarse gritty sandstone, to be hereafter referred to.

On the northern crest of the Divide is a mass of grey ternary granite, which gives place to the metamorphic

schists and intrusive dykes which make up the formation of the Livingstone Creek Valley. Following the creek downwards from the upper moorland flats, which vary in width from 40 to 100 chains, the valley narrows by the near approach of high lateral spurs of contorted mica schist, which in some cases is seen to be intruded upon by masses of quartz-mica diorite. About seven miles from its source, the Livingstone receives a tributary from the east (New Rush Creek), on which are situated some gold workings in heavy auriferous gravels and bouldery wash; many of the boulders are striated and exhibit flat surfaces. On the margin of the raised flats, at the junction of the two streams, are masses of angular detritus in a stiff clay, together with large waterworn boulders and blocks of the quartz-mica diorite of the higher levels, and also some rounded boulders of quartz conglomerate similar to those in the Wentworth Valley, and which, so far as known, do not occur *in situ* in the Livingstone Creek watershed, but which are distributed along the latter to lower levels, and are to all appearance erratics. Some large flattened quartz boulders are also seen similar to the mass which outcrops on the main Divide some twelve miles distant (to the east), viz., at the New Rush Creek. From this point the ranges forming the eastern watershed of the Livingstone are more undulating and lightly timbered, while on the west, high, bold, wooded ranges rise rather abruptly in steep spurs from the creek flats to an elevation of 4000 feet. Near Mount Livingstone—a bold, rounded peak south-west from Omeo—the Livingstone Creek receives an important affluent from the west. This affluent—Jim-and-Jack Creek—although it traverses a rock-bound gorge, where it flanks Mount Livingstone, yet opens out into some richly grassed upland flats and rolling pasture hills, with outcrops of grey, crystalline rocks (gneiss) on the points of the undulating spurs, which show faint traces of striation in the direction of the valley. A low gap separates this area from Parslow's Plains, previously described. At various points in the rocky gorge of the lower part of this stream are rounded hillocks, generally at the termination of spurs at an angle or trend of the valley. They are seen to consist of masses of waterworn boulders in a stiff, tenacious clay, capped generally with gravels of later date. From the junction of Jim-and-Jack with the Livingstone Creek, the latter has eroded its present channel through recurring

masses of boulder clay and auriferous gravels, and heavy transported boulders, &c., for five or six miles to the township of Omeo. It is interesting to note the geological structure of Mount Livingstone in connection with the superficial accumulation of boulders, clays, and gravels at its northern base. The northern spurs and crest of the mountain are made up of bands of mica schist, nodular argillaceo-mica schist, quartzitic schist, intersected by numerous diabasic, dioritic, and porphyritic dykes; and the southern slopes, towards Jim-and-Jack Creek, consist principally of gneiss—gneiss passing into metamorphic granite, with broad dykes of brownish quartz-porphyry and granitite. To the east of Mount Livingstone, the country is more open and undulating for about six miles, until the thickly timbered and steeper rocky spurs from the Great Dividing Range are reached. This lower area of undulating ridges and rounded hills, which constitutes the settled area near Omeo, is intersected by several small watercourses, most of which exhibit what appears to be very distinct evidences of glaciation. One in particular, Deep Flume Creek, contains numerous groovings and markings on the rocky outcrops where the surface soils have been removed on its southern slopes. The creek runs westerly to its confluence with the Livingstone, while the markings are persistently northerly, and vary in diameter and depth from furrows six inches deep and nine inches wide to fine markings—scratches like those made with a sharp instrument. They are also continuous for ten or twelve feet, and cut the strike of the rocks on which they occur. The latter consist of mica schists, hornfels and gneiss; while at higher levels, on the hill-side, masses of an intrusive quartzite are seen to be planed and smoothed down in the direction of the lower markings, viz., that of the Livingstone Creek Valley. In many places, masses of clay and angular débris still cover the markings, while at higher levels the spurs and ridges are capped with gravel. Another creek, Day's Creek, which enters the main stream near Omeo, has on its eastern slopes a rounded hillock, which is abraded and worn down by glacier action; for a hard hornblendic diorite dyke on its northern face is grooved and striated, also in the direction of the Livingstone Creek Valley. The lower courses of this stream have cut through the old lake-bed at Omeo, which extends from Jim-and-Jack Creek, previously described. Another watercourse, Wilson's Creek, which enters from the

same side as Day's Creek, opens out into two branches, each taking its rise in the Dividing Range to the east of Omeo. Along their present courses deposits of heavy waterworn (dyke stone) boulders are frequent, some of which are beautifully striated, particularly the diabase and microporphyrites; while on the points of rocky spurs on its northern slopes are some distinct groovings at an elevation of sixty feet above the present creek bed. On the opposite side of the Livingstone Creek, where this creek joins it, is a deep hollow, worn to a lower level than the former, and filled with immense masses of igneous basaltic rock (large waterworn boulders), many of which exceed eight feet in diameter. These are overlaid by smaller boulders of the various igneous and metamorphic rocks of the valley in a stiff clay, with occasional thick deposits of pipe clay and auriferous gravels. The bed rock is shattered and broken, and in some places rammed with hard quartzose and igneous boulders of smaller dimensions for a foot below the surface. In following the creek upwards from this point these immense igneous boulders are seen to form a continuous line for fully 100 chains (where exposed by the gold workings), and seem to me to represent the products of a lateral moraine extending from Mount Livingstone, where a large glacier filled the valley. A short distance up the creek from this point, where the road to Bingomunjie leaves the Livingstone, a very large mass of andesite igneous rock, fully ten feet in diameter, and with the lower side flattened and planed down, is seen to rest on a friable yellow clay, the latter crammed with angular and rounded rock fragments—a veritable still, the igneous boulder being surrounded and overlaid by auriferous gravels, bouldery wash and clays. A mile higher up, on the eastern margin of these deposits, and also on the east side of the Livingstone Creek, is situate the township of Omeo. The gold workings *in situ* afford excellent means of studying the relation of the different materials filling up the old lake-bed. The section across these deposits at Dry Hill, about a mile west from Omeo, is given. These deposits have been cut through by a small western affluent—Dry Gully. There is a basin-shaped hollow near its source, below some auriferous quartz veins, which is also filled up with a deposit of heavy boulders, clays, and auriferous gravels, known as Power's Gully, at an elevation of 900 feet above the Dry Hill area.

Following the Livingstone Creek downwards from Wilson's Creek junction the hills on each side are more or less planed down in flowing outlines, while masses of dense grey gneiss, which outcrop on the hill-sides, are in some places polished and striated, presenting a moutonné appearance. Three miles lower down, another depression, or old lake-basin, called Hinnomunjie Swamp, is reached. Here are seen deposits similar to those at Dry Hill, while the adjoining hillocks are abraded in rounded undulatory outlines. Still lower, at the junction of the Livingstone with the Mitta Hinnomunjie Station flats, is another basin filled with similar materials. The present course of the Livingstone seems to have eroded its channel in some places quite out of the courses it assumed in Pliocene times, notably between Wilson's Creek and Hinnomunjie Swamp, and between the latter and Hinnomunjie Flat, where the Pliocene river-bed was more to the westward, under the steep ridges proceeding from Mount Bingomunjie range.

From the evidences supplied by the various markings, the heavy bouldery deposits, and what I believe to be heaps of morainic débris in the Livingstone Creek valley, I think it is highly probable that we have here represented at least three interglacial periods since Pliocene times.

1. The deposits of friable, yellow, unstratified clays, as well as that containing the small angular and rounded fragments, seems to me to represent the remnants of a once more extensive moraine profonde, which was the product of the first period of a very extensive area of glaciation during Pliocene times; whether such period of refrigeration be due simply to elevation of the land surface, as suggested by Professor Tate,* or to more complex cosmic and terrestrial causes—such as changes of eccentricity of the earth's orbit; the occurrence of summer or winter in aphelion, in conjunction with the slower or more irregular changes of geographical conditions—these combined causes acting chiefly through the agency of heat-bearing oceanic currents—and of snow and ice collecting highlands, as suggested by Prof. Wallace†; or to the theory of variation of heat of the sun, as advanced so ably by Prof. Siemens, and referred to by Mr. Searles V. Wood, F.G.S. ‡—viz., that

* Anniversary Address, Adelaide Philosophical Society, p. 27.
† Island Life, p. 484.
‡ On the Newer Pliocene Deposits of England, Q.J.G.S., Vol. 38, p. 737.

the heat of the sun is maintained by the combustion of gases diffused in the medium through which it moves, and which are drawn in at the polar and, after combustion, returned by centrifugal force from the equatorial parts of the sun into space.

Extensive sub-aërial denudation and a warmer climate succeeded the breaking up of this first period of Pliocene glaciation. Another, although less severe, refrigeration took place, culminating in a second glacial period, during which the surface contours of the more prominent low-lying ridges near Omeo were greatly abraded, and during the latter part of which the heavy boulders of the Dry Gully, &c., false bottoms were deposited, as well as the erratics and blocs perchés of the Livingstone Creek valley. This was followed by a period of comparative repose, when sub-aërial denudation was slower and less active, a warmer and more equable climate prevailing. During this time the pipe-clays, white gravelly wash, and sand-beds overlying the false bottom at Dry Gully were deposited in the still icy waters of this ancient mountain tarn. The fragments of fossilised wood in the above deposits would also seem to prove that the surrounding ranges were covered with a luxuriant timber vegetation of myrtaceous genera, probably forms allied to Eucalyptus Pluti. A third and final period of glaciation occurred, less extensive than either of the preceding, at the breaking up of which the auriferous gravels, clays, and boulders of the Livingstone Creek were deposited, and also the finer gravels on the ridges near Omeo and along the spurs abutting on the Livingstone Creek. The whole of the present surface configuration on the undulating ranges near Omeo, the Victoria Plains, and Jim-and-Jack Creek, seems to me to have been originally moulded by ice action; indeed, unless we accept the hypothesis of glacial abrasion, it seems difficult to account for the rounded and flowing outlines in a rock formation which elsewhere under sub-aërial influences presents surface contours bristling with craggy peaks and rugged surfaces. I have elsewhere* sought to explain this peculiar feature of the ranges in the Livingstone Creek valley, and in the other sources of the Mitta Mitta, by differences in the amount of rainfall and the slower degrading influences of frosts and snows; but on viewing the orographical features in the light which the

* Physical Features of the Australian Alps, Trans. Roy. Soc., Vict., Vol. XXI.

glacial evidences afford in this valley, it seems difficult to resist the conviction that the present smooth outlines are mainly due to ice erosion. Another fact which seems to support this view is, that in recent times the erodation and denudation that is taking place under sub-aërial conditions presents sharper and more rugged outlines in the sides of the gullies and creeks.

In an inquiry into the causation of these ancient mountain lakes or tarns, we may consider three different hypotheses —

1. That they were caused by oscillations of the level of the surface, such as that produced by faultings and other dislocations, and consequently might be pre-glacial.
2. That they were formed by the erosive action of glaciers.
3. That they were formed by the building up of terminal moraines at the close of, or during, a glacial epoch.

The first of these propositions in a district which has been subjected to violent convulsions, such as that occupied by portion of the Mitta Mitta source basin, may appear possible. For at Day's Hill—a rounded elevation situate near Omeo, and at the lower extremity of the old lake-bed —there is an intrusive mass of granitoid rock, which has sent out numerous radiating dykes of felso-porphyrite and quartz porphyry; while associated with the former are massive outcrops of quartz. One of these quartzitic out-flows, or intrusions, crosses the lower end of the lake-bed near Wilson's Creek junction, and might have caused the barrier to the discharge of the upper valley at this place if it had been intruded subsequently to the excavation of the latter; but, from the geological surroundings, these intrusions are contemporaneous with the larger intrusive mass at Day's Hill, which *à fortiori* is regarded as probably Devonian, and consequently intruded long prior to the excavation of the Livingstone Creek valley. Faultings of the metamorphic schists in this valley are plentiful enough; yet no such dislocation of the surface has yet been found at those points where they might be considered to have produced a depression or elevation resulting in the formation of existing lake-basins. It must not be forgotten that eminent geologists in examining those districts elsewhere, where similar geological conditions exist, and where probably similar climatic influences prevail, such as the highlands of Scotland (the land of breaks and faults), have remarked that instances where a fault could be said to be even a

proximate cause of a lake-basin are extremely rare, if any at all exist; while numerous instances have been given of Scottish lochs having been scooped out by the erosive power of glacial ice in unbroken strata. It does not appear probable that the origin of the Livingstone Creek old lake-beds is to be ascribed to any pre-glacial earth movements.

2. That they were scooped out by the erosive action of glaciers is more in accordance with the observed facts. The seeming difficulty in the apparent want of sufficient slope in the valley may be answered by the well-known fact, "that the slope of the upper surface of a plastic or fluid substance determines the rate of the flow, and not that of the under surface; since, if ice were accumulated over a region so that the upper surface had the requisite slope, there would be motion in the mass in the direction of this slope whatever the bottom of the slope might be. At the same time the slope of the land at the bottom or the courses of the valleys would determine to some extent the movement of the bottom."* In this case there would in all probability be a sufficient slope to allow of a proper down-thrust of the glacier mass at each of the localities previously referred to, and the consequent rasping and carving-out of the lake-beds by the harder rock fragments in the glacier bottom. I am sensible of the difficulties which beset the theory of glacier excavation on mechanical and physical principles†, but the facts observed in the Dry Gully area can be more satisfactorily explained by the theory than by any other means.

3. Should, however, the slope be considered insufficient for erosion of the hollows, there are not wanting evidences that the filling up was accelerated by the building up of terminal moraines, where subsidiary lateral glaciers joined the medial valley glacier. The heavy materials deposited at the junction of New Rush, Jim-and-Jack, Dry Gully, and Wilson's Creek are striking evidences of such. Objections may be raised to the cross markings or striæ on the sample of volcanic rock produced in illustration of the evidences referred to in this paper, that "the scratches take such a variety of directions, and occur in a manner that hardly appears reconcilable with the idea that they were caused by the passage of other materials under the grinding power of ice;" but we must remember that, "as water is always

* Text Book of Geology: Dana, p. 224.
† Mechanics of Glaciers: Rev. A. Irving, B.A., Q.J.G.S., No. 153, p. 73.

flowing under some parts of a glacier, and much melting and relegation of ice are going on in different places, stones are liable to change their position, in which case a second set of striæ and furrows may be imprinted in a new direction. In like manner, the solid rock underneath the glacier may exhibit scratches and grooves in more than one direction; the furrows will, most of them, coincide with the general course of the valley; but as the ice in different seasons varies in quantity the direction of its motion at a given time is not uniform, so that the grooves and scratches will also vary, one set often intersecting another."* Again, it may be said that the samples of mica schist present only weathered parts along cleavage lines and at softer spots; but this objection may be met by stating that the groovings are found exactly in that position where the grinding and gouging power of glacial débris under the ice sheet would be most likely to prove effective, and that the groovings are persistent across the cleavage lines as well; and further, that no similar markings are found on similar rock masses in other parts of the valley, although exposed to the degrading influences of atmospheric agencies.

The rounded outlines of the gneissic and other metamorphic rock masses on the hill-sides may also be attributed to mere weathering; but the striations on these outcrops which cross the bedding planes and cleavage lines seem to offer indisputable evidences of glacial abrasion. They occur also at what was probably the mean height of the latest valley glaciers—*i.e.*, along the margin or edge of the latter.

It must not be forgotten that the evolution of the existing contours of the Australian Alps during tertiary times was dominated over large areas by the violent volcanic outbursts which occurred in early Pliocene times. The immense sheets of basalt which now form the Dargo, Bogong, and Paw-Paw Plains—the latter at the head of the Victoria River, and which sealed up the Miocene river-beds—are striking evidences of the volcanic activity of that time; while the deep valley of the Dargo River, some 1500 feet below the Miocene river-beds, is still more striking evidence of the enormous erosion which subsequently took place in that valley.† Mr. Murray, our able Government geologist, has informed us ‡

* Lyell's Geology, p. —.
† Southern Science Record, 1885, p. 12.
‡ Geo. Sur., Vict., Vol. VI., p. 41.

that "it is probable that the outlines of all the main drainage courses of the tertiary period, whether Miocene or Pliocene, were formed early in the former epoch . . . No submergence below the sea to an elevation exceeding 900 feet above the present level appears to have taken place during or since tertiary times. Had there been no lava flows, the general course of the rivers above that elevation would have remained unaltered until the present day." So that the influences which dominated in the carving out of the surface configuration of the Australian Alps during Pleistocene times were certainly sub-aërial; and, for the reasons assigned in this paper, it appears to me that we must concede the point sought to be established by Mr. Griffiths, in his admirable paper, "On the Evidences of a Glacial Epoch in Victoria during Post-Miocene Times"—viz., that Australia, as well as South Africa, South America, and New Zealand, participated in a glacial period.

In another article I hope to adduce further evidences of glaciation in the Mitta-Mitta sources, and also direct further attention to the question of interglacial periods; but, in concluding the present paper, have much pleasure in acknowledging the receipt of an interesting paper by Dr. von Lendenfeld, of Sydney,* in which that savant gives the results of his explorations of the Kosciusko plateau during January last, establishing the fact of the glaciation of the highest mountain in Australia, although that gentleman's inferences as to the area over and altitude at which traces of glaciation would be found to occur are somewhat at variance with the evidences herein presented. In tabulating his interesting results, the learned doctor informs us, page 9: "The climate was then not very cold, so that the glaciers only covered the highest part of the Australian Alps, and were consequently very small." If my evidences are correct, the glaciers would not only have covered the whole of the Australian Alps, but might have extended their influence to the lower levels down the Murray basin. Again, at page 4, it is stated in reference to the snow patches that—"These snow patches are never found in 'deep ravines,' as Mr. J. Stirling states.† Snow patches such as those on Kosciusko only lie close to the exposed parts where

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* The Glacial Period in Australia, by R. von Lendenfeld, Ph.D.: Trans. Soc., N.S.W., Vol. X., p. 45.

† Southern Science Record: Remarks on Flora of Australian Alps.